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ABSTRACT

One of the goals of quality education in Pennsylvania is to help every student acquire knowledge, understanding, and appreciation of science and technology. This publication, which focuses on the technology component of this goal, is an initial effort by a team of scientists and science educators to define technology as it should be presented in an educational program and to devise classroom activities which will help the teacher to adequately present an overview of technology and its implications for society. It includes: (1) a list of 18 suggested student competencies related to knowledge and appreciation of technology; (2) a list of suggested topics and activities for each of the 18 competencies; and (3) comments by James A. Michener on "The Anti-Science Epidemic." Included in an appendix are additional activities for these topics: technology; possible effects of future technologies (cyrogenics, cloning, and the matter-antimatter reactor as an inexhaustible energy supply); technology and morality; recombinant DNA and interferon; rockets; printing; aluminum; explosives and society; recombinant DNA; and the assembly line. Also included is a list of additional topics for study and sources of free and inexpensive materials on technology. (JN)

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TECHNOLOGY

MEETING THE TECHNOLOGY PORTION OF THE SCIENCE AND TECHNOLOGY GOAL OF QUALITY EDUCATION

"Quality education should help every student acquire knowledge, understanding and appreciation of science and technology."

Pennsylvania's Goals of Quality Education

Division of Health, Science and Technology
Bureau of Curriculum Services
Pennsylvania Department of Education

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COMMONWEALTH OF PENNSYLVANIA
STATE BOARD OF EDUCATION

GOALS OF QUALITY EDUCATION

PREAMBLE

The Constitution of the Commonwealth of Pennsylvania states, "The General Assembly shall provide for the maintenance and support of a thorough and efficient system of public education to serve the needs of the Commonwealth." This provision mandates a quality education for each child in the Commonwealth.

The schools have the primary responsibility for the achievement of the goals of quality education as established by the State Board of Education, but they must work in close and continuous cooperation with the family, community and other appropriate social, religious and governmental institutions to insure the highest possible achievement of the goals.

To foster achievement of a quality education, the school environment should be safe, attractive and orderly, promote a willingness to work for objectives, stimulate a readiness to continue learning throughout life, and encourage the fullest possible educational development of each student.

To foster achievement of a quality education, the school program should reflect the following goals:

COMMUNICATION SKILLS
Quality education should help every student acquire communication skills of understanding, speaking, reading and writing.

MATHEMATICS
Quality education should help every student acquire skills in mathematics.

SELF-ESTEEM
Quality education should help every student develop self-understanding and a feeling of self-worth.

ANALYTICAL THINKING
Quality education should help every student develop analytical thinking skills.

UNDERSTANDING OTHERS
Quality education should help every student acquire knowledge of different cultures and an appreciation of the worth of all people.

CITIZENSHIP
Quality education should help every student learn the history of the nation, understand its systems of government and economics and acquire the values and attitudes necessary for responsible citizenship.

ARTS AND HUMANITIES
Quality education should help every student acquire knowledge, appreciation and skills in the arts and the humanities.

SCIENCE AND TECHNOLOGY
Quality education should help every student acquire knowledge, understanding and appreciation of science and technology.

WORK
Quality education should help every student acquire the knowledge, skills and attitudes necessary to become a self-supporting member of society.

FAMILY LIVING
Quality education should help every student acquire the knowledge, skills and attitudes necessary for successful personal and family living.

HEALTH
Quality education should help every student acquire knowledge and develop practices necessary to maintain physical and emotional well-being.

ENVIRONMENT
Quality education should help every student acquire the knowledge, and attitudes necessary to maintain the quality of life in a balanced environment.

March 9, 1979

PREFACE

Science vs. Technology

There is a distinction between science and technology which should be understood. Science refers to the accumulation of knowledge about natural phenomena. It includes not only the knowledge itself, but also the interpretation of the knowledge and the methodology by which such knowledge is gained. Technology refers to the activities which result in the production of materials and services. It is largely through technological development that economic and social progress can be achieved. It is commonplace for laypersons to speak of science when they really mean technology. Science and technology can and do interrelate but they are not synonymous.

The use of basic knowledge by applied scientists and technicians requires the lapse of a variable period of time. Basic knowledge cannot be technologically applied until it is available and understood and until the practicality of the knowledge is appreciated. Once these criteria are met, it is only a matter of time before application occurs.

Once the actual use of the new product by society occurs, society must adjust to the changes resulting from the new development. These changes may or may not be easily predictable. One of the greatest problems resulting from the use of scientific knowledge in technology arises when application follows discovery in such short order that there is little time to anticipate possible adverse consequences. In this report, technology becomes involved in moral issues, whether such involvement is desirable or not.

FOREWARD

The present commitment to the Pennsylvania School Improvement Project is a commitment which is long overdue. The heart of the School Improvement effort is an intensive in-depth self-assessment by local school districts, using local and outside consultative help and a carefully constructed and followed plan, addressing how the local district will improve student achievement in the Twelve Goals of Quality Education.

This publication is devoted to the Science and Technology Goal of Quality Education. It is an initial effort by a team of scientists and science educators to define technology as it should be presented in the educational program, and to devise classroom activities which will help the teacher to adequately present an overview of technology and its implications for our society.

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SUGGESTED STUDENT COMPETENCIES IN TECHNOLOGY

The outcomes of technological change have radically altered human destiny. Civilizations have flourished or declined as a direct result of their technological progress. For this reason the State Board of Education promulgated the Science and Technology Goal of Quality Education which states:

> "Quality education should help every student acquire knowledge, understanding and appreciation of science and technology."

The following 18 suggested student competencies are presented to provide teachers with a sense of direction for instruction concerning technology and its effect upon our daily lives.

Teachers may wish to add to this competency list or to delete one or more competencies in some grades. The list as it appears below is not meant to be covered by each teacher in each grade, but serves as a recommended compilation of exit competencies, to be achieved by a student by the time of graduation.

Student achievement in understanding technology is not the sole responsibility of the science teacher. The effects of technology often are societal, and so should be included in most subject areas.

In order to demonstrate a knowledge and appreciation of technology, the student should be able to:

1. Develop a working definition of technology.

2. Describe the impact of technology upon his/her quality of life.

3. Compare and contrast similarities and differences between pure and applied sciences. (Science and technology).

4. Describe some of the effects of the applications of technology on the following:

   a. communication
   b. housing
   c. transportation
   d. health, length, and quality of life
   e. food production
   f. energy distribution
   g. national defense
   h. energy resources
   i. religion
   j. economics
   k. political systems
   l. ethics and law
   m. population density and distribution
   n. natural resources
   o. family life

5. Identify and analyze some of the difficulties in predicting the effects of technology upon society.

6. Explain how the rate of new applications of science and the proliferation and quality of technology will be a reflection of the chosen life style of a society.

7. Compare and contrast the application of technology in a developed versus an underdeveloped society.

8. Illustrate that technology per se lacks morality, but since society determines its use, the development of new technologies may have moral implications which must be considered.

9. Give examples to show that all segments of a given society do not benefit equally from technological advances.

10. Describe technological development in individual nations as a function of monetary reserves, societal needs and cultural values.

11. Describe how technological advances have radically altered history.

12. Discuss the rationale and effects of anti-technological attitudes.

13. Explain that the results of technology may involve benefits and risks that were not foreseen prior to the development of that technology.

14. Provide examples of how technological choices represent an acceptance of risks in order to obtain benefits.

15. Demonstrate an awareness that the human life span is too short to determine the effects of many technological changes. (historical references)

16. Demonstrate that scientific and technological literacy is a universal need as a data base for decision making.

17. Demonstrate that technological innovations often yield new information that may create additional technological innovations (spin-off effect).

18. Demonstrate by citing hisotrical examples that future technological progress will require an analysis of the effect and impact of that technology upon the community.

SUGGESTED TOPICS FOR THE STUDY OF TECHNOLOGY

The following list of activities are the result of a "brainstorming" session involving the members of the Technology Task Force. This is not meant to be a comprehensive list of activities, but rather to serve as a beginning list to be augmented by the ingenuity of the teacher. No grade recommendations are made. This is left to the teacher's discretion.

Competency 1: Develop a working definition of technology

1.1. Use the dictionary to determine the root of the word technology and its working definition.

1.2. Do the same to define the word technician.

1.3. Go to the library. List the topics of the books in the Technology section.

1.4. Name several technicians in your community and name the technologies they represent. Describe the work they do.

1.5. List and define all the fields of technology you can think of.

Competency 2: Describe the impact of technology upon the quality of life.

2.1. Interview your grandparents or other elderly persons in your community to determine the following.

a. How was their house heated when they were young? How is it heated now?

b. How were their available foods different from today, especially in winter?

c. What did they do for entertainment? Travel? Communication?

d. What consumer products which are common today did they lack?

e. How did they get to school? Church? Errands? Take long trips?

f. Invite senior citizens to speak to your class concerning any of the above topics.

2.2. What happened in the famous New York City power failure? Describe conditions during the blackout.

2.3. What would today's citizen have to do without if we didn't have electricity?

2.4. Which technologies are used in your school cafeteria?

2.5. How was food preserved in the America of 1630? How is it preserved today?

2.6. How is a modern American kitchen different from a kitchen of 1900?

Competency 3: Compare and contrast similarities and differences between pure and applied science. (Science and Technology).

3.1. Consult the dictionary for the meaning of the above two terms. (Also consult a science textbook and an encyclopedia).

3.2. Go to the library. Contrast the topics in the Pure Science and the Technology sections.

3.3. How does the "pure" scientist use technology? Give examples.

3.4. Give examples of how technology affects the rate of growth of pure science?

3.5. Are the processes used by the scientist and the technolgist the same?

3.6. Give examples of how the findings of pure science are applied by the engineer or other technologist. (e.g. - a wire becomes hot when electricity is forced through it due to the wire's resistence. Applications: light bulb, toaster, electric stove, electric fry pan, water heater, home heating system.)

Competency 4: Applications of Technology

Suggestion: Display the **Foxfire** books. Have students select a topic to demonstrate or discuss.

Each of the following could be studied in a historical perspective, emphasizing developments in each category.

4.1. Communication

a. Compare the methods and length of time it took to send a message from coast-to-coast from the arrival of Europeans in America to the present. Do the same with transcontinental transportation.

b. List and describe present-day methods of communication which were non-existant in the year 1900.

c. Visit a post office, radio or TV station, the telephone company and/or your local newspaper.

4.2. Housing

a. Compare housing from colonial times to the present. Emphasize construction materials, plumbing, heating and lighting. Build models of various housing types.

b. What housing construction materials are in common use today which were unavailable in the year 1900? (Example: aluminum siding.) What are their advantages?

c. Visit a lumber yard to view new materials. Collect samples. Write to the manufacturers for information on development.

4.3. Transportation

a. Discuss how modern transportation has changed the American lifestyle.

b. Compare the methods available and the required time to travel from Philadelphia to San Francisco in 1800, 1850, and 1980. How might we travel in the future?

4.4. Health, Length and Quality of Life

a. Compare the expected life span of an American born in 1900 with that of an American born in 1980. Why has this come about?

b. List drugs available today which were not available 10 years ago. Have a pharmacist speak to your class.

c. Discuss how medical technology has contributed to the prevention and control of disease.

d. Interview an older physician to determine how medical practice has changed since their training.

e. Why do we no longer require that pre-school children be vaccinated for smallpox?

f. List other diseases which have been mostly eliminated.

4.5. Food Production

a. List machinery found on today's farm.

b. Describe modern poultry or livestock growing methods. Visit a farm, hatchery, or dairy to observe these methods.

c. Can food be grown without soil? Describe how.

d. Discuss the interrelationship between petroleum supply and farm productivity.

e. What percentage of the American population are farmers?

f. Invite your County Agricultural Agent to be a guest speaker.

4.6. Energy Distribution

a. Discuss how energy is distributed. (electricity, gas, coal, oil, gasoline)

b. Is there really an energy shortage or is it a distribution shortage? Validate your answer.

c. Name and describe the energy alternatives to petroleum and how these supplies would be distributed.

4.7. National Defense

a. Discuss how national defense depends upon technology.

b. Compare the weapons of war over the past century. How have they changed?

c. How did the invention of gunpowder and other weapons alter world history?

4.8. Energy Resources

a. Compare the major energy sources in America during colonial times and the present.

b. List new energy sources which have been developed during the past 30 years.

c. Describe new energy sources under consideration and their possible effects upon our society.

4.9. Religion

a. Discuss how TV has possibly changed religious practices.

b. How has technology altered religious missionary efforts?

4.10. Economics

a. Discuss how economic development depends upon technology.

b. What did you or your family purchase this year that was not on the market 5 years ago?

c. Describe the technology available in an underdeveloped nation such as Java.

4.11. Political Systems

a. How has electronic communication affected our electoral system?

b. How has electronics affected the reporting of national election results?

c. Name several technological decisions which have affected our political system.

4.12. Ethics and Law

a. How have hidden television cameras in stores and banks affected shoplifting and robberies?

b. What laws have been passed concerning electronic surveillance?

c. How have computers aided law enforcement agencies?

d. How might the improper use of computers violate a person's civil rights?

4.13. Population Density and Distribution

a. How have the automobile and improved roads affected where people live and what they do?

b. How might the rising cost of transportation affect where people live?

c. How has technology affected family size?

4.14. Natural Resources

a. How have the demands of technology depleted our natural resources?

b. How might technology help conserve natural resources?

4.15. Family Life

a. How has technology affected:

1. Family size?
2. Family health?
3. Family lifestyles?
4. Communication with distant family members?

b. How has technology aided ailing or crippled family members?

Competency 6: Understand that the rate, proliferation and quality of technology will be a reflection of the chosen life style of a society.

6.1. Read and discuss Toffler's **Future Shock**.

6.2. Have students interview their grandparents or other elderly persons to determine lifestyles in their youth and how their lifestyles changed in later years due to technological change. Be sure to include:

a. Food preservation and seasonal foods
b. Transportation
c. Clothing and fabrics, maintenance of clothing.
d. Home heating and lighting
e. Leisure time activities
f. Communications
g. Plumbing

6.3. Bring in guest speakers to discuss life on an Early American farm. Have them bring in artifacts such as a butter churn, or any other items suitable to their presentation.

6.4. Have your students prepare presentations concerning life styles in underdeveloped nations. Compare these lifestyles with their own.

6.5. Interview an executive from a local industry concerning changes in manufacturing in the last several decades.

6.6. Define your desired "quality of life". What part does technology play in maintaining it?

6.7. List inventions and discoveries which you would like to have available in the future.

Competency 7: Compare and contrast the application of technology in developed and underdeveloped societies

7.1. Compare the average home and its equipment for cooking, heating and lighting in America, in Liberia, and in India.

7.2. Compare agricultural methods in America and Korea.

7.3. Discuss the concept of the Green Revolution in underdeveloped nations.

7.4. Study the level of industrialization in Japan and China.

Competency 8: Illustrate that although technology lacks morality, since society determines its use, the development of new technologies may have moral implications which must be considered.

8.1. Have the students choose the most beneficial and harmful inventions of the last 20 years (in their opinions). Do a risk/benefit analysis for each.

8.2. Discuss the moral issues which are involved in the use of:

a. Dynamite
b. Nuclear energy
c. Herbicides
d. Cloning
e. Sperm banks
f. Recombinant DNA
g. Life support systems
h. Drugs

8.3. Discuss what obligation society has to insure the proper use of technology.

8.4. Discuss the effects of strip mining coal on:

a. The nation's energy supply
b. The environment.

Competency 9: Understand that all segments of a given society do not benefit equally from technological advances.

9.1. Prepare papers or presentations concerning technological advances and their effects upon person of different economic and/or geographic backgrounds.

9.2. List several advantages and disadvantages of various technological changes.

9.3. Trace the development and use of computers. Identify categories of those persons affected by their use, and how they are affected.

9.4. Interview representatives of the following groups of people to determine their reactions to the development of exurban (rural) areas:

a. Farmers
b. City planners and administrators
c. Suburban residents
d. Soil conservationists.

9.5. Organize a debate to justify suburban development.

9.6. Debate the premise that increased production of gasohol is the answer to the gasoline shortage.

9.7. Invite a meteorologist to discuss the causes and possible effects upon the peoples of the world of:

a. Acid rain
b. Increased CO_2 production
c. General atmospheric pollution

9.8. Determine the effects of increased energy prices on:

a. The rich
b. The middle class
c. The poor

Competency 10: Understand that technological development in individual nations is a function of monetary reserves, societal needs and cultural values.

10.1. Interview (or invite as guest speakers) foreign exchange students, resident immigrants, or visitors from foreign nations to discuss technological developments in their respective countries.

10.2. View films of lifestyles in foreign lands.

10.3. Select an undeveloped nation and analyze its technology.

10.4. Compare the degree of food processing in individual nations.

10.5. Discuss the validity of claims for "natural foods."

Competency 11: Describe how technological advances have radically altered history.

11.1. Discuss the disease smallpox. How widespread has it been and how was it eradicated? (Ask your students if they have been vaccinated.)

11.2. Discuss how the invention of the following have radically altered history:

a. Printing
b. Gunpowder
c. Nuclear energy
d. The internal combustion engine
e. Electronic communications
f. The electric light
g. Add others at your discreation

Competency 12: Discuss the rational and effects of anti-technological attitudes

12.1. Read and discuss the attached article by James Michener

12.2. Discuss the following:

a. Hippie movement
b. Natural foods advocates
c. "Back to the Earth" movement

12.3. How might this attitude effect future supplies of scientists and engineers?

Competency 13: Explain that the results of technology may involve benefits and risks that were not foreseen prior to the development of that technology.

13.1. Explain the unforeseen risks which followed these technological changes:

a. Building the Welland Canal to open the St. Lawrence Seaway. (Sea Lampreys entered from the Atlantic Ocean and destroyed the Great Lakes fishing industry.)

b. Drilling water wells in Venice, Italy. (The city is sinking into the marsh.)

c. Irrigating desert land in Arizona. (The land became salty and unfertile.)

d. Development of coal mines. (Acid mine drainage destroyed life in streams.)

e Use of DDT as a pesticide. (Does not degrade, but shows up in human tissue. Has nearly exterminated the American eagle by affecting egg resistance to breakage.)

f. Development of Aerosol Sprays. (Fluorocarbons in upper atmosphere prevent the blocking of ultraviolet rays from the sun. This will result in increased skin cancer.)

g. Development of detergents. (Phosphates caused degradation of waterways due to increased plant growth.)

h. Construction of new Department of Energy Windmills in North Carolina. (Vibrations broke windows and cracked plaster walls for 30-mile radius.)

i. Development of high tension electric lines. (Radiation exposure to those nearby; destruction of wildlife habitat.)

13.2. Ask your local druggist for product information folders enclosed with prescription drugs. Study these to determine precautions or contraindications.

13.3. Collect labels from foods and discuss the ingredients. What is the purpose of non-traditional ingredients?

Competency 14: Provide examples of how technological choices represent an acceptance of risk in order to obtain benefits.

14.1. Lead discussions concerning the risks and benefits derived from the applications of technology. For example:

a. The Green Revolution will radically increase the food supply of underdeveloped nations. However, it also entails the expenditure of petroleum for fertilizer, insecticides and herbicides. Fertilizer increases the rate of eutrophication of lakes and streams.

b. Energy production produces pollutants from mining, transporting and burning fuels.

c. Off-shore oil drilling increases the probability of oil spills.

d. Irrigation will make most desert land productive, but keeps needed water from downstream users.

e. The American economy depends to a great extent upon the automobile, but the manufacture and operation of these vehicles causes environmental damage, while accidents result in thousands of deaths per year.

Competency 15: Demonstrate an awareness that the human life span is too short to determine the effects of many technological changes

15.1. Discuss, invite guest speakers, or have the students prepare reports concerning topics such as:

a. Possible genetic effects of radiation from both nuclear plants and the burning of coal.

b. Effects on humans of chemicals and drug therapy (e.g. cyclamates or thalidomide.)

c. Effects on the atmosphere of CO_2 from factories and autos.

d. "Spin-offs" of space age technology.

e. Long-term effects of birth-control on populations

15.2. Trace the long-term effects of technologies over 50 years old. Pay special attention to effects which the original developers did not anticipate.

15.3. Explore the length of the working day from 1800 to the present. How has technology affected it? What projections can we make for the future?

Competency 16: Demonstrate that scientific and technological literacy is a universal need as a data base for decision-making.

16.1. Form debate groups to research and discuss controversial technical issues such as:

a. The formation of energy parks.
b. Dumping solid wastes in deep mines.
c. The necessity for nuclear power and the alternatives.
d. Storage of nuclear wastes.
e. Damming free-flowing streams for electrical generation.

f. Channelization of streams for flood control.
g. The contribution of oil shales in aiding our petroleum shortage.
h. The use of bacteria containing recombinant DNA.
i. Public projects to save endangered species.
j. Should high sulfur coal be burned to meet our energy needs regardless of pollution?

Competency 17: Demonstrate that technological innovations often yield new information that may create additional technologies.

17.1. Space research has produced many "spin-offs" including but not limited to:

a. Microminiaturization (computer chips) used for watches, solid-state devices, calculators, computers.
b. New alloys
c. New materials (teflon, corningware)

17.2. Have your students research and report on other technological "spin-offs" of the space program. (Free booklets are available from NASA). Goddard Space Flight Center, Greenbelt, MD 20771).

17.3. Describe the "spin-off" effects of research in:

a. Plastics
b. Communications
c. Medicine
d. Space travel

Competency 18: Demonstrate that future technological progess will require an analysis of the effect of that technology upon the community.

18.1. Discuss, research or have guest speakers speak on the possible future effects of the following:

a. Recombinant DNA
b. Cloning
c. Space stations
d. Ocean mining
e. Prolonging human life
f. Establishment of data banks
g. Land use
h. Mind control
i. Fusion
j. Recycling technology

James A. Michener Comments on "The Anti-Science Epidemic"

All men and women, especially young men and women, ought to feel themselves engaged in an endless war agains ignorance, for it is through our defeat of ignorance that we have achieved our great triumphs as human beings. Today the war against ignorance stands in curious posture. We have already defeated the problem of illiteracy–anybody in the world today can be literate. We have eliminated the plague in its many forms. We have assaulted the outer barriers of space. We have even grappled with the simpler forms of mental derangement and maiadjustment of the body chemistry. In the conquest of ignorance, we have had tremendous victories.

What we face today, to my amazement, is a phenomenon for which I am not prepared, a counter-revolution against intelligence and especially against science. It disturbs me mightily, even though I am not a scientist and not obligated to the scientific approach.

Perhaps my neutrality entitles me to be more appreciative of the dilemma than I would be if I were deeply involved in it personally. What is sweeping this country and other countries, I fear, is an anti-science movement, a know-nothingism that goes back 200 years, an anti-science hysteria, and the development in politics of an anti-science vote.

This is directly antithetical to the great aims that scientists have had during the centuries. This is a reversal of attitude, and I think we ought to be aware of it. We ought to assess it and, certainly, we ought to combat it.

The Anti-Science Epidemic

Let us consider for a moment what form this anti-science epidemic is taking. On this one brief part of my talk I am perhaps an expert, on nothing else am I; but I have been at the forefront of the anti-science revolution among young people. I have written about it in my novel *The Drifters*, where I was appalled by what was happening to many of our finest and brightest young minds because they were subscribing to this nonsense.

As I worked through the youth movement in those years, I was shocked to find that an enormous number of them were addicted to the I-Ching nonsense, coming out of China, in which it was assumed that a book of recondite material assembled 1,800 years ago was able to produce solutions to current problems.

I was appalled at the number of young people who were taking moral and intellectual and spiritual guidance from the Taro cards. I am today shocked when I turn on a radio station from this community and find that they have on it an astrologer who, when you give your birthdate, tells you what to do for the next five or six years. I was startled at the University of Colorado at Boulder, when I was invited to speak there sometime ago, to check the bulletin boards of the student union and to find not less than nine big expensive advertisements for Indian gurus, each one different and each one with a different doctrine, who were going to explain to the young people of this university the secrets of the universe and how they should reorder their lives. I, who have lived and worked in India, suddenly wondered why, if there is all this intelligence for export, none of it was being applied at home.

I think the young people of Colorado were following very faulty guides indeed, if they felt that they could surrender the whole of the Aristotelian approach to analysis, the whole of the Aquinian approach to morals, the whole of the Thomas Jefferson approach to politics, simply on the word of some guru who applied old falsehoods in a glamorous new light. This seems to be an abdication of reason which I find hard to take. I told the young people, when I met them, that I would stick with the two Thomases, Aquinas and Jefferson, and let them have the gurus.

I have found this rebellion part of a natural rebellion not against science, but against parental authority. They were using scientific aberrations as shock treatment to get the message home to their parents that they were against the whole establishment. And if you're going to be against the whole establishment, what can you do better than throw your whole faith, not in the things that your parents learned at Indiana University or MIT, but in the Taro cards, which will give you a divine insight into things which your parents have completely messed up?

I think that is a large part of it. It is a rebellion against authority, and the most authoritative discipline that the young people come in contact with in their education is the world of science, where certain finite answers are possible.

And this, believe me, is being totally rejected. I think we're going to pay a dreadful price for this. The hopeful thing about it is that this applies only to the general lay public. The education of scientists is going ahead as it always has, and I would suppose the ablest young people I meet today are somewhat better educated than I was at their age. I think they have a brighter promise than I did. So we are dividing our society rather sharply into the elitist group who are at least going through the greater Aristotelian-Socratic approach to learning and tht of Immanuel Kant and Jeremy Bentham and other great analysts. The elite is still being educated at a beautiful level, and I am very pleased with that.

It's the great bulk who are forming deviates from that tradition who are going to endanger our political life and the security of our society. This conflict and competition is going to increase rather than diminish. I find a major characteristic of this revolt the runaway fascination that people of ordinary good sense are now expressing in astrology.

I think it's rather shocking the way the media has surrendered to this, so that major newspapers will devote almost a whole page to the addlepated guesses of someone who has given eighty-eight predictions. One turns out to be almost true, and that proves clairvoyance.

In the high school of my home town, they were giving classes for credit in astrology, and it seems to me that this is such an aberration of intellectual leadership that somebody really ought to protect society against it. It is, I think, a reaction to the post-Sputnik age, and it's understandable. All of us who work with ideas are partly culpable, because in the post-Sputnik age science had a pretty clear field. It swept public opinion. It was given a largess and a freedom which it had not had before, and I am not always sure that it used it wisely. It made too many promises; it antagonized teachers in other disciplines, so that some became leaders in the anti-scientific movement.

Science received too much money without public acquiescence or public supervision. It created a mystique to which the ordinary person was not eligible or invited, and against which the ordinary person turned his or her back. We are now in that period of rejection. Whether this is remediable and reversible, I do not know. I do know that, as someone who is on the firing line myself in these fields, I feel considerable apprehension.

What Do We See Today?

As a consequence of this scientific mood, what do we see today? I come to you as a man somewhat in shock, because I am by nature a scientist, although not so trained. I have never traveled for the last thirty years of my life without a slide rule, in the old days, and now a circular slide rule which I keep in my pocket. I think scientifically and I approach things as scientifically as I can, and what do I find? Trouble.

It seems to me that America's response to Three-Mile Island was about as juvenile and as irresponsible as anything I have ever witnessed. It was hysteria as opposed to studied concern. It was sweeping premature judgment as opposed to calculated analysis as corrective steps. I was economic madness as opposed to cost-effectiveness studied and calculations. It was mob decisions as opposed to the weighing of best alternatives.

I do not see how quasi-scientific economic problems can be settled in that hysterical frame of mind. If sub-intellectual chaos happened then, it could be repeated in years to come. There is a whole universe of problems in which we are going to have to reevaluate, and recalculate, and reestimate costs and make adjustments in our scale of priorities. If we do so on a hysterical basis, I don't see how an orderly society can move ahead. All of us ought to speak out against the hysterical mode of problem solving.

I find it evident again in our handling of the DC-10, I think this manner of grappling with a problem is absolutely as juvenile as anything I could come up with. It's an abdication of intelligence, it's an abdication of normal proble-solving approaches. It's not a solution at all. It's a reversal of all the great traditions by which we reach our judgments. It is a precise duplication of the Three-Mile Island syndrome. It shows the great need for both political leadership and scientific analysis. I would suppose that one of the contributory faults is that people in charge over the past twenty years has not kept the public conversant with what they were doing. When a tragedy hits, there's apt to be an irrational reaction, because preparation has not been made. This is a sorry strategy for a domocracy to adopt for the solution of its complicated problems....

The Factor of Risk

I am especially interested in the moral values involved because I am now working in South Africa on materials and have been doing a great deal of research on the early days of the Cape of Good Hope. Out of every eight or nine ships that passed the Cape of Good Hope in those formative years, the 1500's on, two went down. The costs of linking the great countries to Europe with the equally great countries of Asia were tremendous.

It was not accomplished without vile setbacks, without fears, without apprehensions, without predictions that this could not go on. When one set sail from Amsterdam in the early 1600's to go to Java, one of the great commercial routes of all time, the life expectancy on getting to Java of young men in their very prime of life was a little less than 50 percent. When you went aboard the ship you knew chances were not good that you would ever get there, but the spirit of that period required one to take the risk, and, when enough did, a world of absolute wonder, of enrichment for everyone was attained.

And I think if one looks at Brazil or the Caribbean or the settlement of the United States one finds that same problem, that the cost of getting there was never trivial. It was never 100 percent assured success. It was always an adventure, and those who stayed with the adventure were the ones who sent society forward.

I think that this factor of risk must be kept in mind in the period that we are now involved with. Risk is a fundamental ingredient in scientific advance, whether it be in the abstract sciences, in which I have the greatest interest, or in the applied sciences, like the generation of energy or the development of airplanes. In this adventurous world, there are no securities.

I think that science has been delinquent in creating the impression that there may be. We are now seeing that there are not, and our whole society must be kept informed and instructed on this.

Grappling with Problems

(Another) area in which non-scientific approaches put me in a state of shock is our response to the gasoline shortage. It seems to me that what we have here is the abandoment of leadership, the inability of this nation, with all its computers and all the brilliance of its analysts, to grapple with problems. The inability to tell at any given moment what the supplies of a basic fuel are is, to me, so shocking that I can't come to grips with it.

Had I been director of fuel supplies five years ago, it's quite obvious that the first thing I would have done would be to whip out my circular slide rule and its new improvement–I now work with a HP-25 constantly, and I am through about page 41 of a 181-page manual. I think I have reached my threshold. Anybody who wants the last 100 pages of a good HP manual should see me.

With my calculater I would have said, "Okay, now, what is in the pipeline, what is in the various storage facilities, what are the basic facts?" It would seem to me that any four reasonably intelligent analysts ought to be able to assemble that kind of data and place it on a very secure footing, with an error of plus-or-minus nine.

That is certainly within our capacity. If we have not done it, it can only be because of a malfunction of leadership.

One of the most impressive experiences I have had in my life was in New England many years ago when I wanted to buy a replacement for my car, which had broken down. I was going to get an Oldsmobile. When I went to a dealer–I was then teaching at Harvard and went to a dealer in Cambridge–he had two cars on the floor, and I didn't like either of them. He said, "No problem. Tell me exactly what you want.' I did, and it had about eight characteristics. He said, "Okay, come in Monday, and I'll have it for you."

When I went in, there it was. I was so impressed with such efficiency that I asked him how it had been achieved and he showed me a telegram. He said every Saturday night at 5 o'clock he sent a central clearing house in Boston a coded telegram which (asked) the head office of Oldsmobile in that area where every car within 150 miles was and what its characteristics were. On Sunday he got a cable back telling him where they all were–and for a $20.00 fee he could call another dealer and put a lien on a car, then send his driver over there and get it. On Monday morning he had access to six or seven hundred automobiles. That was my introduction to the fact that management and science working together can organize and do these jobs and can bring rationality into diverse situations.

There's no way that little dealer in Cambridge, by himself, could have supplied my wants. But, with that simple device of exchange of two telegrams, he had the whole strength of the automotive industry behind him. I applaud solutions like that.

In my Naval career, my whole life was turned around, because the Navy had recently adopted a punchcard system, which was very primitive, but did work. As I was completing a very long and arduous tour of duty in the South Pacific, they ran the cards through the punch machine, because they needed somebody who had an MA in history, somebody who had two languages, somebody who had about eight other characteristics–and up came only one card, mine.

Just as I was about to go home, they said, "You know, Michener, we have this wonderful job for you. It will entail two more years, but we think you would be interested because you will have to travel all over the Pacific." It was because of that that I became a writer, so I am a child of the punchcard system.

Swings of Public Opinion

I think that science and people concerned with these applications have been indifferent to the great swings of public opinion, how fast they can happen, with what dazzling speed things can change. I ask all of you to think back four years ago from this day, when our nation was about to make a major decision. How many of you, at that time, even realized that a man like James Carter was in competition for the presidency? It all happened with an overnight swing. There might be today some Republican somewhere, whose name would not come easily to mind to 80 of us, who is in precisely the same situation as Mr. Carter four years ago, with the presidency of the United States right at his fingertips, and we don't even know about it.

I am perhaps more sensitive to those great swings than most, because I deal with them. I wrote a book sometime ago about sports in which I dealt, at some detail, with the great swing that has happened in wrestling. When I was a young man, marvelous, wonderful athletes were wrestling for real–Londos and his crowd–and within three or four years, because of mismanagement and failing to keep the public with them, the whole thing degenerated, and it became a vaudeville show.

I think basketball is in that position right now. It had better make some very, very good decisions, or the public is going to walk away from it. I think we see this in the styling of things for sale; I think we see it in the theatre; we see it in everything; certainly we see it in the field of applied science. If you abandon your intimate relationship with the public, if you fail to keep it with you, you run the grave risk of its walking away from you, the way it walked away from wrestling and the Edsel.

In each of these current problems, space science, as one of our superior intellectual applications, has been delinquent in attending to public relations, by which I mean the keeping of the public in contact with what is happening. Space science has not done a very good job of that, save with the moonshot and, perhaps, the Mars landings.

The pre-disaster preparation in all fields has not been good. Society has been lulled into believing that we have a free ride, and we do not. The quick, solid, masterful decision which may be antithetical to the scientific approach is still one that is forced upon a democratic society. Somehow scientists mut participate in that decision-making process to keep the quick decision from being the wrong decision, or even the disastrous decision. Scientists must cultivate harmony and close contact with political leadership and with the leadership of the media.

If one does not do that, I think one loses the ballgame before the whistle blows because then one has no constituency, no support in time of crisis.

We must keep in mind the speed with which these reverses can be made if one loses touch with the political and media leadership. We think we are so secure in church, and education, and IBM, and writers knowing how to create books. It can all vanish overnight. We become the prey to our mistakes more today than we were a hudred years ago, when the decisions could not be reached so rapidly.

Our job as educated men and women is to ensure that the scientific approach, which has served us so well, is not dissipated. I do not want to see it rest only in the hands of the highly educated 10 or 15 or 20 percent of scientifically trained people. It must have a broader base than that, or scientists become an elite, off to one side, treasured in moments of crisis, ignored when things are going well, indulged as exotics.

The general public must be kept abreast of what science is doing and what its potentials are and what its chances for failure are in any given field. The scientific world must do its job better of providing alternatives for the political leadership. The scientific world must as it has for the past three or four hundred years since Francis Bacon, continue to pursue those goals which history has proved are the soundest bases for the operation of a free society.

APPENDIX I

ADDITIONAL ACTIVITIES

Suggested Activities for Teachers
Technology

Discussion Activities:

1. Discuss the many effects of the automobile upon American society in terms of:

   a. The American economy

   b. Personal lifestyles.

   c. The demise of the city.

   d. Mobility of persons, goods and services.

   e. The energy crisis.

2. Mankind has always found it necessary to communicate with each other. Duscuss the worldwide impact of the development of the following:

   a. The telegraph

   b. The telephone

   c. Wireless radio

   d. Solid state (transistor) radios

   e. Communications satellites

3. Over 300 years ago an English physician named Edward Jenner noticed that milkmaids who had contracted cowpox did not succumb to the dreaded smallpox. He began the practice of vaccinating his patients with cowpox (a very mild form of smallpox) in order to prevent them from contracting smallpox. Other physicians soon followed suit. This eventually led to research in immunication with application to other communicable diseases, such as diptheria, measles, tetanus, whooping cough, poliomyelitis, plague and cholera. Smallpox has been, to the best of our knowledge, eradicated from the earth. Using this background information, attempt to answer the following questions:

   a. What effect has this had upon world population and life expectancy?

   b. We no longer vaccinate people to prevent smallpox. Why not?

   c. Could we eliminate other diseases? How?

d. Discuss the common diseases of 50 years ago with older persons. How has this changed?

e. Should most people be vaccinated against polio? Why?

4. Over the past several decades a drug was found which would reduce the possibility of pregnancy in women to practically zero. When it became generally available, millions of women began using it. As a result, our country over the past several years has maintained a nearly zero population growth rate. Discuss the following:

a. What is happening to the average age of a U.S. citizen?

b. Could this eventually lead to a geriatric society?

c. What effect could this have upon social security benefits?

d. Is a zero population growth rate really beneficial?

e. What effect could this technological advancement have upon underdeveloped nations such as India?

f. At home, what effect has this had upon the public school system? Upon companies who care for infant's needs (baby food, baby clothes, baby powders and other cosmetics)?

5. What has been the effect of the development of national television networks upon:

a. Regional language customs and accents?

b. Family reading habits?

c. Awareness of national and international events?

d. Merchandising of commercial products?

e. Presidential election campaigns?

g. Public safety?

6. Prior to 1800 the main sources of available energy were muscle (both man and animal), and the three W's - wood, wind and water. About then, the steam engine was invented. This device used the heat of burning coal to produce steam. The energy of the steam was converted into rotary motion, which could be applied to power many devices, such as locomotives, mills and manufacturing machinery. This in turn led to the Industrial Revolution and the rise of factories. New rotary engines using fuel such as petroleum were soon developed. Mass production techniques and the assembly line were developed, giving rise to industrial nations.

Using the above chain of events, answer the following questions:

a. How does an initial technological innovation lead to a chain of other technological innovations?

b. Why did the above chain of events trigger the growth of cities?

c. What was the effect upon the distribution of manufactured items?

d. Describe how these events led to the labor movement.

e. What effect did this have upon the quality of the environment?

f. Did this series of events lead to today's energy crisis? Explain why you answered as you did.

g. What effect did this series of technological events have upon the fate of nations?

7. In the year 1800 the typical American farm was a family affair. The farmer, his wife, and his children worked at producing nearly all their basic necessities. His major investment was in clearing his land, plowing, planting, harvesting and animal husbandry. His wife helped on the farm, preserved food for winter use, made the families' clothes from homespun cloth, and managed the household. The children worked at chores according to their ages. Everyone worked from dawn until dusk to provide these necessities. Very few items were bought or sold, and the family rarely left the boundaries of the farm. Animals supplied labor, food and fertilizer, and animal feed was grown on the farm itself.

   By the second half of the 19th Century farm machinery had become commonplace. The first pieces of equipment were powered by horses and mules, later by steam. Today internal combustion engines power tractors to operate the machinery. Farms could be larger because of the efficiency of the machinery, and farms became available as many families moved into towns to become factory workers. Farming became a business, and very few were self-sufficient because of the availability of low cost of manufactured goods. Farmers no longer used their crops themselves, but sold them on the market place, using the money to purchase the needs of the family.

   a. Could these changes have been possible without the invention of farm machinery?

   b. Describe the operation of a modern farm. How does it depend upon modern technology?

   c. Do you think "the good old days" were really that good? Explain.

8. Louis Pasteur postulated that microscopic bacteria were the cause of specific diseases. He was able to produce the disease in healthy animals. His work was confirmed by Koch and others. Once the nature of disease-producing organisms was understood, mankind learned how to deal with them and to slow or stop their spread. Joseph Lister, a surgeon, initiated antiseptic procedures for surgery. Today we have developed the antibiotic drugs which will destroy these organisms. Many dreaded bacterial diseases are now broght easily under control.

   a. Why was Pastuer's work the foundation of today's common health practices?

   b. What effect has this had upon the length and quality of human life?

   c. How has this work improved our food supply?

   d. Why would surgery be useless without antiseptic procedures?

9. Sir Alexander Fleming, a British biologist, was working with bacterial cultures. Spores from a common mold which grows upon and ruins citrus fruits (Penicillium notatum) accidientially fell upon the agar bacterial culture plate and began to grow. Some time later Fleming noticed that no bacteria grew in the vicinity of the mold. He postulated that the mold was producing a chemical substance which inhabited the growth of the bacteria. After strenuous efforts this substance was isolated and named Penicillin after the mold from which it was secured. It was found after exhaustive tests to have the ability to kill bacteria in the human body. It is the first of a series of similar substances called antibiotics. The public nicknamed them "wonder drugs." Serious bacterial infections which formerly either killed the victim or required months or years for recovery were cured overnight. Countless lives were saved.

   a. Have you ever taken an antibiotic for a bacterial infection?

   b. What effect have these drugs had upon human life spans?

   c. Discuss the economic implications of the widespread use of antibiotics.

   d. List several specific diseases which are quickly cured with antibiotics.

   e. List several antibiotics other than penicillin.

10. In the dawn of prehistoric times mankind developed language as a means of communication. This made it possible for people to convey thoughts concerning ideas and objects to each other. This was done by verbalizing one or more symbol which denoted by mutual consent a person, place or thing. When a person heard these symbols a picture of the person, place or thing flashed across his mind. One could speak to another person within hearing distance, or could send a message to another person some distance removed by using a messenger.

Many centuries later symbols were developed to convey messages over distances or time. The earliest writing was probably by use of pictographs - crude pictures incised on stone or clay tablets. Interpreting or producing pictographs was very difficult, requiring especially trained scribes.

Eventually mankind developed the concept of using symbols to represent sounds. Combinations of such symbols could constitute words. All the subtle sounds in a language could be represented by less than 50 such symbols. So, the alphabet was born. Writing and reading were greatly simplified, and an ever increasing number of persons were able to read the written word. Ideas, instructions, laws and records could be maintained, and preserved for generations. Reading became so common, especially after the invention of paper, ink, and printing, that it could even become a pastime, done for personal enjoyment and amusement.

a. Would an advanced civilization as we know it be possible without the written word?

b. Is it possible that electronic voice reproduction might eliminate the written word? Explain.

c. List technological advancements developed to aid in dissemination of the written word (printing press, typewriter, ball point pens, dictaphones, microfilm and microfiche, electronic copies, computers).

Possible Effects of Future Technologies

1. Cryogenics

Today, in a California facility, dozens of human bodies lie frozen in containers at supercool temperatures. These are the bodies of person who have died from presently incurable diseases, such as cancer. Before their deaths they arranged to have themselves quick frozen and maintained in this frozen state until, hopefully, we learn to bring living humans back to life from this frozen state (This, incidentially, has been accomplished with many lower animals), and until we have learned how to cure their presently incurable diseases. The projected plan is to effect a cure to their diseases and restore them to life in a healthy condition.

Although the above process is impossible with today's technology, and actually may never be possible, let us assume that this marvelous task has been accomplished:

a. When this person was pronounced dead his estate belonged to his heirs. Now he is alive, but his possessions are in the hands of others. His heirs may have sold them to a third party. To whom do they really belong?

b. Was this person really dead? What is the legal definition of death? What would his/her legal status be following revival?

c. If this person is over 65 years of age, can he/she receive social security and medicare, or did these benefits terminate with death?

d. What moral issues are involved?

e. Let us assume that this person was revived in the year 2180. Would he/she be able to cope with the society of 2180? Would these persons be able to earn a living in the world of 2180?

f. Having your body maintained in a supercool frozen condition is very expensive. Only the wealthy would be able to afford it. What social issues does this raise?

g. To put into perspective the problems these revived persons would face after a century of storage, let us discuss the following: If a person who died in 1780 were revived today, what problems would that person face?

2. Cloning

Cloning is a method of reproducing living things from a single body cell removed from the body of a donor. The clone has a genetic makeup identical to the donor, and resembles the donor down to the smallest detail. Cloning has been successfully accomplished in plants, and in simple animals. It is possible that, using the proper techniques, human beings could be cloned. A few cells could be removed with a hypodermic syringe from your toe, finger or earlobe. The individual thus produced would, upon reaching your age, be identical to you in every way. It would be impossible to tell you from your clone except for non-genetic characteristics such as wounds, missing body parts, or the like. Your clone would be of the same blood type and have the same hair color and intellectual potential as you do.

Assuming that you live in a time when cloning is done routinely, try to answer the following questions:

a. Is a clone a person? If so, should the clone have a "birth" certificate, be a citizen and have civil rights, including the right to vote?

b. Assume that you are the only child of wealthy parents. Should your clone share inheritance rights with you?

c. How might the world be affected if we selectively cloned intellectual, scientific and educational leaders? For example, how might a few hundred Albert Einsteins affect our knowledge of the universe?

d. What could happen if a dictatorial government decided to clone their best generals, strongest and ablest soldiers, and a large number of slaves to support them?

e. What moral, legal and theological problems could the practice of human cloning raise?

f. How could we improve strains of animals by cloning?

3. The Matter - Antimatter Reactor - An Inexhaustible Energy Supply

For every subatomic particl of matter there is a matching antimatter particle. For example, the proton, a constituent particle of the atomic nucleus, has a positive charge and weights 1.008142 atomic mass units. The antiproton weighs the same, but has a negative charge. When a proton and an antiproton come together they annihilate each other, converting each other's mass into a burst of pure energy equal to about 2,000 electron volts.

A normal atom of matter contains a nucleus of positively charged protons and neutrally cahrged neutrons. The nucleus is surrounded by negatively charged electrons. An antimatter atom, on the other hand, consists of a nucleus of negatively charged antiprotons associated with antineutrons. The nucleus of the antimatter atom is surrounded by positrons, which are positively charged antielectrons. Again, when a matter atom encounters an antimatter atom, both are destroyed, producing aburst of pure energy.

Assume that we have developed a reactor within which matter and antimatter atoms are brought together. Much of the energy from the reaction is produced as heat. The heat is used to produce steam to turn turbines, which produce electricity.

The unlimited electricity produced by this means is produced so cheaply that it is not even metered by the electric company.

a. How would the above scenario affect the price of oil? How would it affect the world political situation?

b. What effect would the above situation have upon the presently underdeveloped nations of the world?

c. What changes could you foresee in both the automobile and in public transportation?

d. Would there be energy-rich and energy-poor nations? How might this affect the world balance of power?

e. With an unlimited energy supply, computer-controlled manufacturing plants and raw materials mined in space and brought back to earth via rockets equipped with matter-anitimatter engines, what effect would occur in:

1. A just distribution of materials and goods.
2. The length of a work day?
3. The price of consumer goods?
4. The relationships among nations?
5. The need for a technologically-trained labor force?
6. The fight against poverty?
7. Extraterrestrial colonies?
8. Space travel?
9. The growth of the aerospace industry?
10. Leisure time activities?
11. The growth of tourism, hobbies, crafts?

Technology and Morality

Science and Technology are processes and methods, and so are amoral. However, the uses to which science and technology are put involve many moral decisions. Any device or process can be put to a moral or an immoral use by the person or persons using that device or process. Technological advances have been used to save lives, alleviate poverty, explore the solar system and to advance human knowledge. Obviously, technological advances have also been used to increase the efficiency of killing other human beings, or to destroy large areas of the environment.

The chemical industry has produced products ranging from modern fibers and plastics to "miracle" drugs to enrich our lives and provide for our welfare. This same industry has, in some cases, improperly disposed of toxic chemical wastes which threaten human life, produced weapons and materials of war, and caused a degradation of the environment.

The pharmaceutical industry has produced drugs to alleviate suffering and cure illness for mankind. But the improper use of these pharamaceuticals by the so-called "drug culture" has produced extensive suffering and death.

Similar statements could be made concerning numerous other aspects of technology. Discuss the following:

1. Discuss the moral implications of any new technology. What factors should be considered?

2. What constitutes a moral or immoral decision?

3. Define "morality."

Recombinant DNA and Interferon

When a human develops a viral disease such as the common cold or influenza, the body produces trace amounts of a very complex protein called interferon. This extremely potent substance destroys the virus, allowing the person to recover.

Researchers felt that if a way could be found to produce interferon in reasonable quantities, it would be possible for the first time in history to cure viral diseases such as the common cold, measles, chicken pox and some types of cancer (which evidence indicates are caused by the invasion of cells by viruses).

On Christmas Eve, 1979, Dr. Charles Weismann working at the University of Zurich, Switerland, found a method of producing this substance using a unique new technology. The human gene which controls interferon production was spliced onto the DNA of a bacterium. The bacterium (E. coli) is easily grown in the laboratory and is able to reproduce every half hour. The large number of bacteria thus produced make interferon, which then can be easily separated from the bacterial culture. Thus, this marvelous new substance not only can be produced, but can be produced cheaply and in large amounts.

Although the final medical tests concerning the effect of interferon on human and animal diseases are yet to come, the potential is awe inspiring.

Now discuss the following:

1. List some human viral diseases which interferon might cure.

2. What is "gene splicing" (Recombinant DNA)?

3. What effect might this development have upon world health?

4. E. coli is a bacteria which is found in the human digestive tract. It is one of the most common bacteria found in human sewage. If recombinant DNA transfer would give rise to a toxin - producing strain of E. coli bacteria, some scientists fear that an uncontrollable worldwide epidemic might result. What methods of handling these bacteria have been developed to prevent this?

Rockets

Rockets move because of Newton's Third Law of Motion. Expanding gases within the rocket chamber are allowed to escape at one end. The resulting action of the escaping gas produces a reaction, the motion of the rocket, which is equal in magnitude and opposite in direction to the force of the escaping gas.

Probably the first rockets were made by the Chinese, and were fueled by gunpowder. They were fired as "Chinese Arrows" from city walls in time of attack.

Robert Goddard developed the first liquid-fueled rockets. His work was to lay the foundation for the giant military and space exploration rockets of the 1950's.

Rockets carry their own fuel and a tank of oxidizer to burn the fuel. For this reason they operate independantly of the atmosphere, and continue to operate in space.

1. Construct a timeline of the history of rocketry including:

The Goddard Rocket	The German V-2
Begining of US Space Program	Sputnik I
First Manned Orbiter	Lunar Landing
Skylab	Venus Exploration
Weather and Communications Satellites	Space Shuttle

2. What effects have the space program had upon:

   2.1 Weather forecasting
   2.2 Microminaturization (electronic)
   2.3 New manufactured products
   2.4 Worldwide communications
   2.5 Warfare
   2.6 Medical monitoring of body functions

3. Describe future applications of the Space Shuttle.

Printing

During the Middle Ages the few books in existence wre laboriously copied by hand in monasteries. Only the very wealthy or the Church owned books, and only the privileged few knew how to read. A monk employed in a scriptorium might spend an entire lifetime laboriously copying manuscripts, most likely the scriptures. Examples of these beautiful documents survive today in museums.

During the early 15th Century, Johann Gutenberg invented a method of printing using movable type. Entire books could be reproduced page-by-page on his hand-operated printing press, and the wooden type could be re-used for new pages. The first book to be printed by this new process was, naturally, the Bible.

Printing soon became commonplace. Messages, advertisements and other written materials were produced in abundance. More and more people learned to read. The knowledge of the ages could be printed and stored for all to use. Essays, instructions and novels were written.

Electrification of the printing press and new printing techniques were developed.

1. What effect did printing have upon:

   a. education
   b. commerce
   c. news transmission
   d. governments

2. How might electronic microminiaturization decrease the amount of printing being done?

3. How would knowledge be passed on without the printed word?

4. In past ages only the wealthy owned books. Estimate the number of books in your home.

5. Why is the printing press considered basic to a free society?

Aluminim - A Modern Metal

Aluminum was first separated from its ores in 1827 by the German chemist Wohler. He found this new metal to have very desirable properties: it was strong, but weighed only half as much as an equal volume of iron; it was non-toxic, had a pleasing appearance, resisted corrosion and exhibited a high thermal conductivity (the ability to transfer heat). It could be easily formed, machined and cast. Moreover, it was found to be a common element in the earth's crust.

It has only one drawback - it was an extremely difficult process to separate it from its ores, and so aluminum was very scarce and very expensive. In fact, it was so rare a metal that Napoleon had knives, forks and spoons manufactured from it for use in the Palace of Versailles.

Aluminum remained a fairly uncommon metal for many years. In 1856 it was valued at $90.00 per pound. At today's inflationary prices this would be equivalent to $2,000 to $2,400 per pound.

In the year 1886 a young chemist named Hall, doing the required research for a Master's thesis developed a way to separate aluminum from the ore alumina by means of electrolysis, after dissolving the alumina in molten cryolite. Hall patented this process and founded a company to produce the metal for commercial purposes. The price eventually fell to 30 cents per pound. Aluminum was put to many diverse uses ranging from cooking utensils to aircraft.

1. What properties of aluminum make it suitable for the following:

   a. Aircraft
   b. Electrical wires
   c. Screen for windows
   d. Cooking utensils
   e. Boats
   f. Housing for compasses

2. How did the availability of aluminum affect developments in space exploration? Aircraft construction?

3. How would the development of processes to produce a new product affect local and national economics?

4. Napoleon originally looked upon aluminum for military applications. Which properties would these applications take advantage of?

5. Why did Hall patent his process of extracting aluminum?

6. Name several common uses of aluminum.

Explosives and Society

During the Middle Ages European society was based upon the feudal system. A typical feudal estate consisted of a large number of serfs or peasants who had sworn fealty (allegiance) to a feudal noble. The serfs worked the land and paid rents in the form of goods, produce and service to the landowning noble. The noble in return governed the estate and, in times of danger, protected the serfs. Most feudal lords maintained a stronghold or castle surrounded by a water moat and a high wall. When an invader appeared the serfs and the noble would barricade themselves within the fortress which contained emergency supplies of food and water, and defend themselves from the castle walls. The invading enemy was usually forced to either scale the walls with ladders, mine under the walls, or knock down the walls and capture the castle by hand-to-hand combat. Another method was to lay siege to the castle and wait until the defenders were forced to come out and do battle as their food or water supplies were exhausted.

The usual weapons of war were the sword, axe, spear, and the bow. Catapults, used since Roman times, were used to hurl large boulders against the castle walls in an effort to batter them down. The crossbow, which shot a bolt with such force that it could penetrate armor, was such a deadly weapon that the Church forbade its use against fellow Christians.

In the thirteenth century, Marco Polo returned from Cathay (China) with a marvelous Chinese invention - gunpowder. The Chinese used this mixture of nitrates, sulfur and charcoal to produce firecrackers and crude rockets called "Chinese arrows."

The Europeans soon found out that the expanding gases of burning gunpowder could expel a projectile from a hollow tube with tremendous force. Cannons were developed which could batter down fortress walls (two or more cannons are still called a battery). Hand-held firearms could fire balls which would pierce armor, wounding or killing the wearer. The day of the invincible knight on horseback was over. Man could now kill his fellow man at long range. The feudal system was doomed.

After reading the above account of the effects of the introduction of gunpowder into Europe, answer the following questions:

a. The use of firearms gave rise to the formation of nations. Why was this so? Who would become the king?

b. Explosives were also put to peaceful uses. List several.

c. Trace the development of firearms from the matchlock to modern weapons.

d. What did this invention have to do with the colonization of much of the world by Europeans?

e. What other effects of the development of explosives and firearms can you list?

Recombinant DNA

The cells of all living organisms contain a large, spiral molecule called Deoxyribonucleic acid, or DNA. DNA molecules are the genes of all living things, from bacteria to man. All inherited characteristics are coded in the DNA molecule, and are passed via this molecule to future generations.

As we learn more about this marvelous molecule, we have learned how to replace parts of the DNA molecule with other, tailor-made portions of DNA, and clone the altered cells to produce organisms with specific characteristics. This altered DNA is called recombinant DNA, and the process is termed genetic engineering.

One organism which has been repatedly altered this way is a bacterium called Escherichia coli. The DNA of E. coli is easily recombined, and these bacteria reproduced by fission, so cloning is unnecessary. One pharmaceutical company has thus developed a strain of bacteria which produces the drug insulin. Now the company is able to produce insulin at an extremely low cost, using their special strain of E. coli, rather than by chemically separating the insulin from the pancreas of slaughtered animals, as was previously done. The company has applied for and received a patent on this strain of E. coli. No living thing has ever before been patented by the U.S. Patent Office.

Many scientists are very concerned about the possible effects of recombinant DNA, especially when using a bacteria such as E. coli which inhabits every human large intestine. They fear that if a disease-producing strain of E. coli should escape from the laboratory, a worldwide epidemic might result, for which we have no vaccine. This could result in widespread sickness and/or death.

The federal government has also become concerned, and has formed the Recombinant DNA Advisory Committee which has the authority to accept or reject proposals from laboratories operating under federal funds to develop specific strains of organisms using recombinant DNA.

Other scientists argue that the scientific community should regulate itself, and that government should not be allowed to control scientific research.

1. Should the government control scientific research?

2. What moral and legal questions are involved?

The Assembly Line

As cottage industries were consolidated into factories, many of the traditional ideas remained in place. For example, a woodworker making a cabinent would work on the same cabinet from beginning to end. Craftsmen were required to learn all the steps involved including cutting, fitting, nailing, gluing, sanding, and finishing the item. Production was slow, but the quality was high.

A young American automobile manufacturer named Henry Ford changed this method forever. In order to increase production and to allow the use of unskilled or partially skilled labor, Ford devised the assembly line.

An automobile being assembled on an assembly line moved slowly along on a movable belt. Each worker was trained to complete only one small part of the assembly process, such as attaching the door handles. This process continues to the end of the line, where the new car emerges. The day of the individual craftsmen was nearly over.

1. Why could an auto be assembled more cheaply on the assembly line than by the traditional means?

2. What effect would the assembly line have upon pride of w ekmanship?

3. What skills should be possessed by a person before being hired to work on an assembly line?

4. What effect has the assembly line had upon the American lifestyle? Upon the availability of manufactured goods?

5. More and more individual American craftsmen are beginning to produce items which are sought after by the buying public. What do you think this signifies?

Additional Topics

1. Orbiting Satellites
2. The Space Shuttle
3. Advances in Surgery
4. Inventions of T. A. Edison
5. Synthetic Fibers
6. Minicomputers
7. Synthetic Fuels
8. Lasers
9. Radar
10. The Green Revolution
11. Sonar
12. Prosthetic Devices
13. Plastics
14. Worldwide Communications
15. Television
16. Hallucinogenic Drugs
17. Interplanetary Exploration
18. Sperm Banks
19. Fission and Fusion Reactors
20. Ocean Mining
21. Intercontinental Air Travel
22. Aquaculture
23. Solar Energy
24. Geothermal Energy
25. Other topics at the discretion of the instructor

Sources of Free and Inexpensive Materials Concerning Technology

A. Media Materials

1. *Search for Solutions*

A Series of nine 20-minute films produced by Phillips Petroleum. Each film is arranged around a problem-solving concept. The film titles are: **Investigation, Patterns, Trial and Error, Contest, Adaptation, Modeling, Prediction, Evidence,** and **Theory.**

Available from:

Search for Solutions Booking Center
708 Third Avenue
New York, NY 10017

2. *Connections*

Sponsored by the Bell System. A 10-part television series on technology and social change. Currently (Fall, 1980), being aired on public television stations for 10 consecutive weeks.

A free "Connections" educational kit is available from:

CONNECTIONS Educational Materials
AT & T College Relations
195 Broadway, Room 540A
New York, NY 10007

3. *What About Tomorrow?*

A film concerning the purpose of scientific research produced for the National Science Foundation. Presents the idea that the effects of basic research may not be immediately realized, but may result in profound changes in the future.

B. Books, Pamphlets, Periodicals

1. *Air and Space*

A mini-magazine of the National Air and Space Museum of the Smithsonian Institution. Available free to teachers by contacting:

National Air and Space Museum
The Smithsonian Institution
Washington, DC 20560

2. *D.T.S. Newsletter* Free

Department of Technology and Society
College of Engineering and Applied Sciences
State University of New York at Stony Brook
Stony Brook, NY 11794

3. *Spinoff, 1979. An Annual Report*

The contribution of new knowledge, methods, materials and devices to technology as a result of the Space Program. Free

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